DEPARTMENT OF DEFENSE
HIGH POWER LASER PROGRAM GUIDANCE

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The DoD investment of nominally $200 million per year is focused on four high power laser (HPL) concepts:

- Space-Based Laser (SBL), a Ballistic Missile Defense Organization effort that addresses boost-phase intercept for Theater Missile Defense and National Missile Defense,
- Airborne Laser (ABL), an Air Force effort that addresses boost-phase intercept for Theater Missile Defense,
- Ground-Based Laser (GBL), an Air Force effort addressing space control, and
- Anti-Ship Missile Defense (ASMD), a Navy effort addressing ship-based defense.

Each organization is also supporting technology development with the goal of achieving less expensive, brighter, and lighter high power laser systems. These activities represent the building blocks of the DoD program to exploit the compelling characteristics of the high power laser.

Even though DoD's HPL program are focused and moderately strong, additional emphasis in a few technical areas could help reduce risk in these programs. In addition, a number of options are available for continuing to use the High Energy Laser System Test Facility (HELSTF) at White Sands Missile Range. This report provides a brief overview and guidance for the five efforts which comprise the DoD HPL program (SBL, ABL, GBL, ASMD, HELSTF).

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Executive Summary

The DoD investment of nominally $200 million per year is focused on four high power laser (HPL) concepts:

- Space-Based Laser (SBL), a Ballistic Missile Defense Organization effort that addresses boost-phase intercept for Theater Missile Defense and National Missile Defense,
- Airborne Laser (ABL), an Air Force effort that addresses boost-phase intercept for Theater Missile Defense,
- Ground-Based Laser (GBL), an Air Force effort addressing space control, and
- Anti-Ship Missile Defense (ASMD), a Navy effort addressing ship-based defense.

The Air Force, with 37% of the funding in FY94, is addressing the ABL and GBL concepts. The Ballistic Missile Defense Organization (BMDO), with 30% of the funding, is addressing the SBL concept. The Army, with 14%, is principally supporting the High Energy Laser System Test Facility (HELSTF) and the Navy, with 4%, is addressing ASMD. Each organization is also supporting technology development with the goal of achieving less expensive, brighter, and lighter high power laser systems. Small Business Innovative Research (SBIR) and Basic Research programs, plus exploratory development efforts at ARPA, account for the remainder of the funding. These activities represent the building blocks of the DoD program to exploit the compelling characteristics of the high power laser. All of these efforts are coordinated through semiannual information exchange meetings and more frequent informal exchanges.

For all four concepts, an important issue is packaging of the high power laser and associated acquisition, tracking, pointing and fire control (ATP/FC) systems to meet platform size, weight, and reliability constraints. Specific program guidance is as follows:

- Space Based Laser (SBL) [BMDO]: The Space-Based Chemical Laser Program is an element in the BMDO strategy to achieve a long term, effective ballistic missile defense capability. Boost-phase intercept is the key to effective ballistic missile defenses across a broad range of emerging threats. A high power laser based in space offers potential for the unique capability of continuous, global, boost phase intercept of ballistic missiles. SBLs can potentially provide robust theater and national missile defense with one system. Remaining issues are ATP/FC and integration of subsystems for a space-based platform. BMDO should establish the feasibility of applying lethal fluence on ballistic missiles at militarily useful ranges from a space-based platform. Ongoing integration programs, Alpha Lamp Integration (ALI) and High Altitude Balloon Experiment (HABE), should be completed as planned. Efforts will continue to accomplish the generation and control of a full-power HPL beam by the end of FY96 under ALI, and full-up passive and active tracking demonstrations by the end of FY98 under HABE. After the completion of ALI, the ALI hardware and designs will be

repackaged into an operational configuration. A conceptual design and program plan for this demonstration, System High Energy Laser Demonstration (SHIELD), has already been developed. In SHIELD, ALI hardware and designs will be repackaged, mated with an ATP suite, and ground tested. Upon completion, a policy option will be available to mate SHIELD with a launch vehicle for a space demonstration. Technology base efforts should continue to be supported in high power HF (including overtone) lasers, uncooled optics, phase conjugation, autonomous alignment and advanced ATP/FC technologies. Increased emphasis will be placed on autonomous alignment and automation, high power non-linear optics for beam clean-up and control, and uncooled resonator optics.

The BMDO SBL program will be structured to allow for appropriate review and oversight. A detailed SBL program review will be prepared and presented at the end of ALI (tentatively the end of FY96), detailing implementation of this guidance and outlining decision criteria for each program segment.

- Airborne Laser (ABL) [Air Force]: The ABL effort offers a potentially valuable in-theater asset to accomplish boost phase intercept of theater ballistic missiles. The concept is based on a capability that would enter the theater ready-to-fight and operate in friendly airspace a considerable distance from the battle area. The Air Force should establish the feasibility of applying lethal fluence on theater ballistic missiles at militarily useful ranges from an airborne platform. Remaining issues include high altitude atmospheric characterization, atmospheric propagation and tracking, laser device performance, adaptive optics, and target vulnerability. The Air Force will continue efforts to develop a thorough understanding of propagation and lethality issues for target kill and a concept for aircraft packaging with respect to laser power and beam control by the end of FY97. At that time the ABL program will be reevaluated with emphasis on accomplishments, the status of alternative concepts and threat, prior to continuation to the ABL Demonstrator. Technology base efforts that support both ABL and GBL should continue in high power COIL lasers, active track/ illuminator/ artificial beacon lasers, atmospheric propagation and aimpoint designation, and next generation technologies. Increased emphasis will be placed on device technology (scaling/packaging, efficiency), atmospheric propagation (turbulence, illuminator phase information, jitter), and simulation and modeling (to assess concept of operations and mission requirements).

- Ground Based Laser (GBL) [Air Force]: The GBL effort is developing imaging and weapon technologies for application to the space control mission. A GBL system has the potential to perform the anti-satellite (ASAT) mission through the precision engagement of a specific aimpoint on a satellite and deposition of sufficient laser energy to degrade or destroy critical

satellite components through thermal damage. The GBL system required to provide this capability involves a high-power laser device and a sophisticated beam control system. Remaining issues include ATP, beam control, high power atmospheric propagation, and device scaling. The GBL program will continue to address issues of ground-to-space high power beam propagation culminating in a fully integrated low power beam control demonstration by the end of FY99. An understanding of vulnerability issues and a system analysis and concept definition will also be completed in preparation for a program decision in FY99. Technology base efforts described above to address both ABL and GBL requirements will continue with increased emphasis on device scaling and high power atmospheric propagation.

- Anti-Ship Missile Defense (ASMD) [Navy]: The Navy is investigating the potential of HPL technologies for the ship-based self defense mission. A high power laser system has the potential to provide significant improvements in ship self-defense by defeating a variety of anti-ship cruise missile threats, regardless of the type of seeker used for missile guidance. Laser weapons for ship self-defense appear much more practical and feasible when the cold-war nuclear keepout range requirement is reduced to address non-nuclear cruise missiles. The physics and lethality data for a high irradiance continuous wave chemical laser system have been extensively addressed. The Navy Point Defense Demonstration (PDD) is the final activity in a series of tests spanning the last two decades. The program has engaged crossing targets at subsonic and supersonic velocities. The head-on scenario is in progress and will be completed in FY94 using actual anti-ship missiles as targets. At the conclusion of the PDD in FY94, the Navy will assess the utility and effectiveness of an HPL system for ASMD. At present, no out-year funds are specifically programmed for continued development.

- High Energy Laser Systems Test Facility (HELSTF) [Army]: HELSTF is the only high power laser test site that is equipped and staffed to support tests against flying vehicles. It also has the nation's only fully instrumented high power laser range and environmentally approved test area. Current uses include a Navy Point Defense Demonstration, an ABL lethality demonstration, and use of the HELSTF Sea Lite Beam Director for high resolution imagery of BMDO kinetic energy intercept demonstrations. No funds are programmed to operate HELSTF beyond FY94. The Joint Directors of Laboratories Technology Panel for Directed Energy Weapons will examine the role of HELSTF as an affordable and cost-effective DoD RDT&E facility to support national HPL and optical tracking programs. They will determine how the site could be configured (facilities and organization) to address users' needs at reduced overhead cost. The assessment will examine the utility of retaining other-than-MIRACL facilities as well as the entire facility. If no funded requirements for use of the Mid-Infrared Advanced Chemical Laser (MIRACL) have been identified, in FY95 the Army will proceed with closing down the MIRACL facility.

- Technology Base Efforts: The technology base supporting DoD HPL applications is well defined, but it is not robust. Limited 6.1 and 6.2 funding is being applied to next generation (i.e., emerging, high-risk, high-payoff) laser technologies such as free-electron lasers, solid-state lasers, semiconductor lasers, and other advanced concepts which could bring unique capabilities such as wavelength tunability, high efficiency, and compactness to the HPL programs. The guidance above requires continued support for specific technology development to accomplish near/mid term program objectives and continued support for specific emerging, high payoff technologies to meet far-term requirements. This program guidance will continue a balanced, coherent technology base for the long term.

INTRODUCTION

In the changing political climate of the world today, with shrinking defense budgets likely in the foreseeable future, the Armed Forces of the United States will increasingly rely on advanced technology to maintain the advantage over their adversaries. Desert Storm was a prime example of this principle, where advanced weapons technology allowed an unprecedented one-sided victory over a powerful, well equipped, dug-in enemy force. Guidance from DDR&E has established a strategic vision for DoD that includes evolutionary improvements in weapon systems (rather than a constant development and fielding of totally new systems), reliance on innovative, highly leveraged "breakthrough technology" to maximize the return on investment in Defense acquisition, and exploitation of "technology trump cards" to sustain long term technological dominance. One such area where the United States has traditionally held a technological edge is in the field of laser technology.

Twenty years ago, laser rangefinders were novel systems. Today, the laser rangefinder is an integral part of nearly every fielded weapons system and has tremendously enhanced the Services' ability to target and engage hostile forces with greater first-round speed and accuracy. As we move forward, mid-power laser radars, spoofers, jammers and counter-sensor systems are serious candidates to further enhance US military capability.

As the threats to our ground, sea, air, and space forces become more sophisticated, so must our response to those threats. For example, theater ballistic missiles, such as the SCUDs used by the Iraqis during Desert Storm, will become more accurate and lethal with the addition of multiple warheads, submunitions, or possibly weapons of mass destruction. These pose a difficult problem for conventional defense systems. Even the advanced interceptors being developed under the auspices of the Ballistic Missile Defense Organization (BMDO) may be stressed by the addition of submunitions or countermeasures. Likewise, we can expect to see a proliferation of low cost but capable UAV surveillance and indirect weapon system spotting in the relatively near future. These threat systems, and others like them, are the driving force behind the extensive effort in DoD to develop high power laser (HPL) technology as a potential cost effective weapon concept.

Similarly, by the year 2005 and beyond, naval forces may have to deal with supersonic missile threats that will fly less than 3 meters above the water and maneuver at high *g* rates. These weapons will be hard to detect and more difficult to kill with conventional defensive systems. Lasers may have the potential to defeat fast sea skimming missiles, to intercept theater ballistic missiles during their vulnerable boost phase, to provide space control and to offer a response in other unique situations where more conventional weaponry may not be adequate or affordable.

This hope is founded in the unique properties of laser weapons, including:

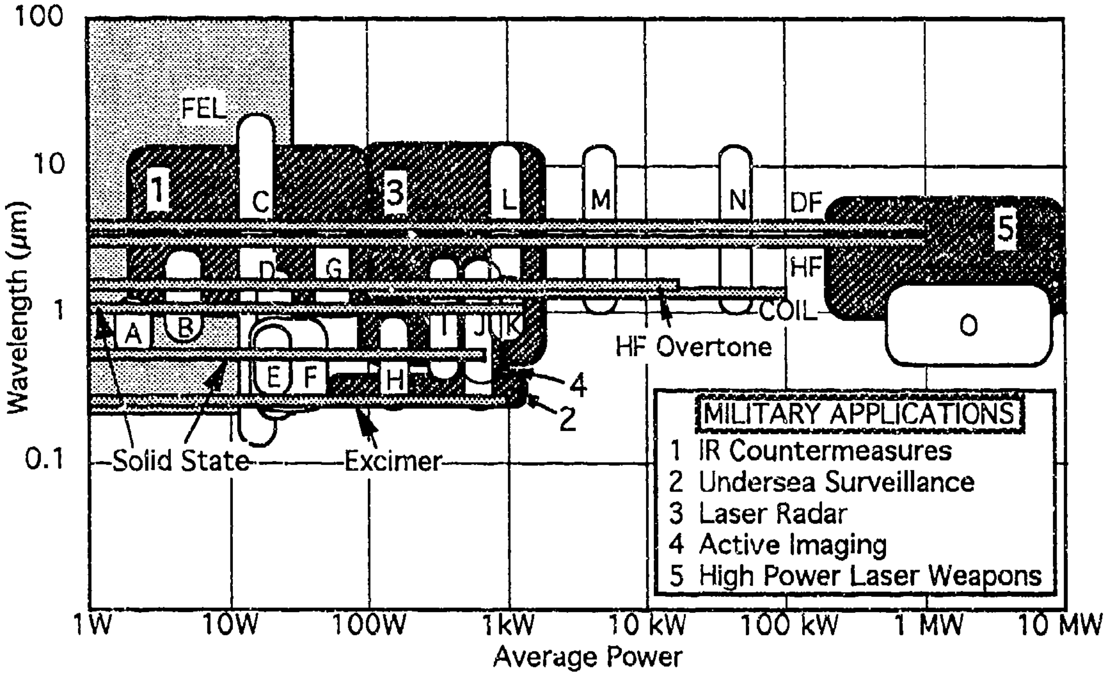
- Laser energy propagates at the speed of light, allowing a laser weapon to engage anything it can see, almost as soon as it sees it.
- Depending on the source of energy for the laser (chemical tanks, electrical power, etc.), laser weapons have a "deep magazine", i.e. they can engage a large number of targets before having to reload or replenish supplies. The munitions expended, i.e., photons, are relatively cheap, with the high cost weapon system retained, resulting in favorable cost exchange lethality.
- A laser destroys a target by depositing a controlled spot of thermal energy on the surface of the target, or anywhere the laser beam can penetrate the target (such as on a sensor system). It is extremely difficult to harden a target against both laser and kinetic weapons systems.
- A laser can offer alternative "kill mechanisms", particularly against threat electro-optic sensors which will proliferate on the battlefield of the future. This may include selective temporary negation of particular systems without the need for total catastrophic destruction of the target.
- Laser technology has obvious applications in industry, medicine, and basic research. The development of high power lasers which are reliable, compact, and relatively inexpensive (all worthwhile goals for militarily useful lasers) promises a number of civilian spinoff applications in these areas. For example, the ARPA solid state laser program, as part of the TRP, could lead to a very effective laser machining capability. Thus, military laser programs can and do positively impact the nation's economic competitiveness through an improved industrial base.

It is for these reasons that DoD is pursuing the development of the technology basis for a number of laser weapon systems. As a minimum, understanding the limitations of laser systems (by doing research on them) can preclude surprise from foreign employment of such weapons. Some of the current DoD programs are in the basic research stage, some are more advanced and are nearly ready to engineer into a usable system or place "on the shelf," depending on resources and funding priorities. <u>Each has its own unique characteristics which allow it to best address one or more military missions. There is no single laser device which can be "all things to all missions</u>" any more than there is a single optimum RF device for all applications. Also, the larger, more sophisticated laser systems tend to come to fruition farther in the future. The nearest term laser systems are lower power, with applications such as imaging, rangefinding, target designation, and sensor jamming.

Civilian applications for laser technology range from lower power optical communications (Watts) to high power space power beaming (Megawatts). Figure 1 shows the power and

wavelength requirements for a variety of military and civilian applications. The overlap between military and civilian applications is clear. The Services are investigating a range of laser technologies to address these applications. The most promising of the HPL devices in the near term are the Deuterium Fluoride (DF) chemical laser operating at 3.8 μm, the Hydrogen Fluoride (HF) chemical laser which can operate at 2.8 μm or at 1.4 μm (HF overtone), and the Chemical Oxygen Iodine Laser (COIL) operating at 1.3 μm. The Free Electron Laser (FEL), solid state and other advanced concepts bring additional unique capabilities such as tunability and compactness. Demonstrated performance levels for each of these technologies is indicated in Figure 1.

Figure 1
Dual Use Applications of High Power Laser Technology



CIVILIAN APPLICATIONS		
A CD Players	F Reprographics	K X-Ray Lithography
B Optical Fiber Comm	G Tissue Cutting	L Heat Treatment
C Remote Sensing	H Photodynamic Therapy	M Cutting/Welding
D Weather Sensing	I Eye Surgery	N Robotic Welding
E TV, Entertainment	J Circuit Repair and Marking	O Power Beaming

The DoD Service and Agency HPL efforts and their supporting technologies are presently supplying emerging laser technology to the civilian sector. Figure 2 summarizes dual use transition opportunities. Initiatives are underway to transfer DoD laser/optics technology to the commercial sector in the areas of industrial welding, medical research, power beaming, astronomy, materials processing, surgery, and space communications. New collaborations are under investigation in optical lithography, imagery, and remote sensing.

Figure 2
HPL Dual Use Transition Opportunities Matrix

Dual Use Application	HPL Technology	DoD Effort	Transition Status
Industrial Welding	Laser Laser	GBL ARPA-TRP	Initiative underway - CRDA Initiative underway - CRDA
Medical Research	Laser Laser	FEL SBL	Initiative underway - CRDA Under Investigation
Lithography	Laser	FEL	Under Investigation
Power Beaming	Laser & Optics	GBL	Initiative Underway
Astronomy	Optics Optics	GBL SBL	Initiative Underway Under Investigation
Materials Processing	Laser Laser	HELSTF GBL	Under Investigation Initiative Underway
Surgery	Laser	AF Semiconductor Laser	Initiative Underway
Imagery	Laser	SBL	Under Investigation
Optical Components	Optics	GBL SBL HELSTF	Under Investigation Under Investigation Under Investigation
Space Communications	Laser Optics	AF Semiconductor Laser GBL	Initiative Underway
Remote Sensing	Laser	GBL	Under Investigation

OVERVIEW OF DoD HPL PROGRAMS

Just as low and mid power laser systems satisfied battlefield deficiencies and improved our military's warfighting capability, so too will high power lasers fill voids which are emerging on the twenty-first century battlefield. As global technology enables tactical and strategic weapons to become faster, more agile and more lethal, speed-of-light defenses become more and more essential. HPLs provide both a technical and tactical advantage over potential adversaries and a hedge against surprises.

During FY94, the DoD has three 6.3A program elements, Ballistic Missile Defense (BMDO PE 63217C), Advanced Weapons Technology (Air Force PE 63605F), and DEW Technology (Navy PE 62111N), which include HPL technology development supporting Theater Missile Defense, National Missile Defense, Space Control, and Anti-Ship Missile Defense missions. Note that these program elements support many technologies which then feed into the HPL efforts. For example, PE 63605F supports an advanced technology base in beam control, imaging, and high energy lasers for both the Airborne Laser (ABL) and Ground-Based Laser (GBL) efforts. Similarly HPL efforts in PE 63217C, which are shifted to PE 63218C in FY95 and beyond, support an advanced technology base in chemical lasers and in acquisition, tracking, pointing,

and fire control (ATP/FC) for the Space-Based Laser (SBL) program. Thus, each program element supports advanced technologies which are common to and strongly leverage the HPL efforts for that program element. The specifics for these HPL efforts are listed below:

HPL Effort	Mission	User
Space-Based Laser (SBL) - BMDO Effort	Theater Missile Defense and National Missile Defense (NMD)	USSPACECOM (Targeted User)
Airborne Laser (ABL) - AF Phillips Laboratory Effort	Theater Missile Defense (TMD)	USAF Air Combat Command and Air Materiel Command
Ground-Based Laser (GBL) - AF Phillips Laboratory Effort	Space Control	USSPACECOM
Point Defense Demonstration - Navy Effort through FY94	Anti-Ship Missile Defense (ASMD)	PEO - Theater Air Defense (Targeted User)

Note that DoD fully supports these mission areas with Operational Requirements Documents (ORD) and Mission Needs Statements (MNS). The HPL Programs provide, in each case, unique capabilities not found in other approaches to these missions.

HPL TECHNOLOGY BASE

The DoD has a moderately strong, focused, and coordinated technology base supporting the HPL efforts identified above. The most promising laser devices in the near term are the hydrogen fluoride (HF) chemical laser, the deuterium fluoride (DF) chemical laser, and the chemical oxygen iodine laser (COIL). These lasers are the backbone of DoD's HPL programs. Limited funding is being applied to next generation (i.e., emerging, high-risk, high-payoff) laser technologies such as free-electron lasers, solid-state lasers, semiconductor lasers, and other advanced concepts which could bring unique capabilities such as wavelength tunability and compactness to the HPL programs.

Note that appropriate down-selection processes (driven in large measure by funding constraints) have eliminated a number of laser technologies from contention in DoD's HPL programs. For example, excimer, dye, CO_2, and FEL lasers are not budgeted by the DoD for its HPL programs. Congressional adds to DoD budgets continue to support research efforts in these and other laser technologies. These adds totaled more than $60M in FY94.

The technology base supporting DoD HPL applications is well defined, but it is not robust. The program guidance that follows requires continued support for specific technology development to accomplish near/mid term program objectives and continued support for specific emerging, high payoff technologies to meet far-term requirements. This program guidance will continue a balanced, coherent technology base for the long term.

HPL PROGRAM GUIDANCE

Even though DoD's HPL program are focused and moderately strong, additional emphasis in a few technical areas could help reduce risk in these programs. In addition, a number of options are available for continuing to use the High Energy Laser System Test Facility (HELSTF) at White Sands Missile Range. The pages which follow provide a brief overview and guidance for the five efforts which comprise the DoD HPL program:

- Space-Based Laser (SBL)
- Airborne Laser (ABL)
- Ground-Based Laser (GBL)
- DEW Anti-Ship Missile Defense (ASMD)
- High Energy Laser System Test Facility (HELSTF)

Space-Based Laser Effort (BMDO funded)

The Space-Based Chemical Laser Program is an element in the BMDO strategy to achieve a long term, effective ballistic missile defense capability. Boost-phase intercept is the key to effective ballistic missile defenses across a broad range of emerging threats. The high power laser based in space has the potential to deliver lethal irradiance over ranges exceeding 4000 km to destroy theater and strategic ballistic missiles. The HF SBL penetrates the atmosphere to about 35,000 feet (or cloud tops, if present), providing the potential for intercepts early in boost phase. Numerous studies have addressed the potential of the SBL for ballistic missile defense. The SBL concept offers effective solutions to tactics and payloads designed to exhaust and/or saturate terminal and midcourse phase defenses such as salvo launches and early release chemical, biological, or high explosive submunitions. As a boost phase intercept system, the SBL complements initially deployed kinetic energy (hit-to-kill) terminal and midcourse theater ballistic missile defenses. Continuous theater coverage may be possible with 12 or fewer platforms. The same SBL system deployed for theater missile defense could provide capability for national missile defense as well. Due to the potentially large effective ground range and broad multi-mission capability of the SBL, high military payoff is forecast with the first deployed platform and is enhanced by each platform added. Because of this potential, SBL defenses may be extremely cost effective.

GUIDANCE - SPACE-BASED LASER
REPRIORITIZE WITHIN PRESENT FUNDING LEVEL

Pursue SBL program to Alpha/LAMP Integration (ALI) and ATP/FC completion

Accomplish, with subsystems traceable and scalable to operational SBL requirements:

- Generation, control and projection of HPL beam to known values of outgoing wavefront error, jitter, and boresight by FY96
- Full-up passive tracking demos by FY97
- Full-up active tracking demos by FY98

Continue support for technology development to accomplish program objectives:

- HF-overtone lasers
- Uncooled optics
- Stimulated Brillouin scattering phase conjugation
- Autonomous alignment technology
- Advanced ATP/FC technologies

Action Items

- Increase emphasis on autonomous alignment and automation, high power non-linear optics for beam clean-up and control, uncooled resonator optics
- Structure the SBL program to allow for appropriate review and oversight.
- Prepare and present a detailed SBL program review at the end of ALI (tentatively the end of FY96), detailing implementation of this guidance and outlining decision criteria for each program segment.

Airborne Laser Effort (Air Force funded)

The potential of an airborne high energy laser to engage multiple missiles during their boost phase has led to the ABL concept being identified as a strong candidate for an additional tier to the Theater Missile Defense (TMD). The inherent advantages of this weapon concept are: it destroys the missile during boost phase when it is highly vulnerable and can be easily detected and tracked; it engages the missile prior to release of any submunitions; and debris resulting from missile destruction may fall back on enemy territory. The ABL is a highly mobile platform and provides employment flexibility not available with land-based systems. The system is designed to enter the theater ready-to-fight and operate in friendly airspace a considerable distance from the battle area where, along with other high value airborne assets in the theater, it is supported by defensive aircraft to enhance survivability. In addition, the ABL has the potential for self-defense as demonstrated by the Airborne Laser Laboratory in flight experiments conducted over ten years ago. An ABL brings additional ancillary capability to the theater battlefield. Under clear line-of-sight constraints, the ABL may have potential against cruise missiles, airborne targets, and battlefield surveillance systems. The ABL concept is supported by the Air Force Air Combat Command and Air Materiel Command.

GUIDANCE - AIRBORNE LASER
REPRIORITIZE WITHIN PRESENT FUNDING LEVEL

Pursue ABL Advanced Technology and Demonstrator Development phases to end

Accomplish:

- Propagation and lethality understanding with respect to target kill
  - Atmospheric considerations
  - Target vulnerability
  - Beam stability
- Aircraft integration packaging issues with respect to laser device and beam control for beam quality, power, etc.

Continue support for technology development to accomplish program objectives:

- COIL lasers - recycling, high efficiency
- Illuminator lasers
- Atmospheric compensation and characterization and precision tracking
- Artificial beacons
- Limitations and effects of high power lasers

Continue support for emerging high payoff technologies at present level:

- High power semiconductor and solid state lasers
- Advanced optics
- Advanced atmospheric compensation

By end FY97

Action Items

- Increase emphasis on device (scaling/packaging, efficiency), atmospheric propagation (turbulence, illuminator phase information, jitter), lethality, and simulation and modeling (to assess concept of operations and mission requirements) to reduce program risk in these areas.
- Following technology development and concept design phases (FY97), reevaluate effort for continuation considering accomplishments, status of alternative concepts and threat

Ground-Based Laser Effort (Air Force funded)

A GBL system has the potential to perform the anti-satellite (ASAT) mission through the precision engagement of a specific aimpoint on a satellite and deposition of sufficient laser energy to degrade or destroy critical satellite components through thermal damage. Additionally, in some specific satellite engagements, satellite optical sensors may also be vulnerable to disruption by saturation, provided that the laser is in-band and within the field of view of the sensor. The GBL system required to provide this capability involves a high-power laser device and a sophisticated beam control system. The laser device must produce the required power level for relatively long run times (up to 100 seconds), while maintaining good beam quality. The beam control system as a whole is required to accomplish laser beam clean-up; delivery of the beam from the laser device to a large-aperture transmitting telescope; artificial beacon and wavefront sensing technology which can effectively sense the distortions which are induced by propagation through the turbulent atmosphere; adaptive optics to correct both optical beam train and atmospheric-induced distortions; satellite target acquisition and tracking; target identification; aimpoint designation and maintenance; and damage assessment. The GBL concept is supported by the US Space Command.

GUIDANCE - GROUND-BASED LASER
REPRIORITIZE WITHIN PRESENT FUNDING LEVEL

Pursue program to ATTD end to establish performance of GBL system

Accomplish:
- Fully integrated beam control demonstration at low power
- Satellite vulnerability understanding
- System analysis
- Concept definition

Continue support for technology development to accomplish program objectives:
- COIL lasers
- Active track/illuminator lasers
- Artificial beacons
- Atmospheric compensation
- Aimpoint designation and maintenance
- Limitations and effects of high power lasers

Continue support for emerging high payoff technologies at present level:
- High power semiconductor and solid state lasers
- Advanced optics
- Advanced atmospheric compensation

By end FY99

Action Items

- Increase emphasis on device scaling and high power atmospheric propagation to reduce program risk in these areas.
- Maintain plan for program decision in FY99.

DEW Anti-Ship Missile Defense Program (Navy - unfunded after FY94)

The operational assignments of surface combatants are rapidly expanding because of the need to operate in a dramatically diversifying threat and political environment. Naval weapons must be able to deal with supersonic missile threats that will be less than 3 meters above the water and maneuvering at high g rates. A high power laser system could provide significant improvements in ship self-defense by defeating a variety of anti-ship cruise missile threats, regardless of the type of seeker used for missile guidance. The physics and lethality data for a high irradiance continuous wave chemical laser system have been extensively addressed.

The Navy Point Defense Demonstration (PDD) is the final activity in a series of tests spanning the last two decades. The program has engaged crossing targets at subsonic and supersonic velocities. The head-on scenario is in progress and will be completed in FY94 using actual anti-ship missiles as targets. This test series addresses a key vulnerability issue. With successful completion of these last lethality tests, the Navy will have achieved most of the fundamental performance goals that it established under the Sea LITE Program. A weapon-level HEL system has been successfully developed and its ability to destroy missiles in flight will have been demonstrated. At the present time, no out-year funds are specifically programmed for continued development.

FINDINGS - ANTI-SHIP MISSILE DEFENSE

- Current Point Defense Demo at HELSTF investigating efficacy of high power laser devices for shipboard self defense against actual threat targets in head-on geometries
- Full scale laser device, beam director, and ATP have been built and demonstrated
- Steps to an operational system include:
  1. Successful completion of PDD (fully funded, FY94)
  2. Shipboard compatibility demo which addresses operational packaging issues (unfunded)
  3. Demonstration at sea (unfunded)
  4. Full-scale prototype (unfunded)

Action Items

- Pursue D&V testing program to accomplish clear understanding of head-on vulnerability issues in Navy PDD tests by end FY94.
- At the conclusion of the PDD in FY94, assess the utility and effectiveness of an HPL system for ASMD against current and near-term non-nuclear cruise-missile threats.

High Energy Laser System Test Facility (Army - unfunded after FY94)

HELSTF currently supports high power laser programs in the areas of concept development and demonstration, damage and vulnerability assessment, optics development, high power atmospheric propagation, and acquisition, pointing and tracking. In addition, the Sea Lite Beam Director (SLBD) has been used as a very effective long-range dynamic imaging system in support of various theater missile defense missile/target intercept demonstrations. The missions assigned to HELSTF by the US Army Space and Strategic Defense Command are:

- Maintain and operate the High Energy Laser Systems Test Facility.
- Be prepared, on order, to perform an anti-satellite contingency mission.
- Maintain site safety and environmental standards at or exceeding Federal and New Mexico state standards.

The site location in the middle of White Sands Missile Range (WSMR), combined with data links to US Army Space Command, gives HELSTF the ability to tie together a wide range of test scenarios. The result is the Integrated Battlefield Experimental Testbed (IBEX) concept. The existence of operating hardware means that customers can test a wide variety of concepts without expending a large amount of resources on hardware acquisition and installation/ integration. The data links with the WSMR enable real time data flows from any system at WSMR into and out of HELSTF. This link provides the ability to conduct tests with other systems, providing the only capability for evaluating and exploring methods of integrating Kinetic Energy systems (missiles and guns) with Directed Energy systems (lasers) on a battlefield. The full spectrum of engagement problems can be looked into, from basic command and control to actual firing sequences and battle damage assessments. The capability and flexibility of the site permit a wide range of studies, from tactical battlefield and ship engagements through strategic missile engagements and even space operations (both simulated engagements and imaging/ tracking missions). In addition, the site can be used to determine susceptibility of US systems, both tactical and strategic, to laser radiation. The site also has the capability to incorporate any new HPL currently under development in its facilities.

FINDINGS - HIGH ENERGY LASER SYSTEM TEST FACILITY

- Only integrated, megawatt-class laser facility (MIRACL/SLBD, Mid-Infrared Advanced Chemical Laser and Sea LITE Beam Director)
- Only fully instrumented HPL range and environmentally approved test area
- Planned use for Navy Point Defense Demo and ABL lethality demo
- Experiments assess feasibility of 3.8 μm system for ship point defense
- No future upgrades to the MIRACL currently programmed by the Services
- 220 full time equivalents/$25M needed per year to maintain existing site. (40 people/$5M per year needed to maintain existing SLBD) Reductions in personnel not possible due to non-automated nature of MIRACL. If operating personnel are released from the program, then they are not available for any future laser missions.

Action Items

- Joint Directors of Laboratories Technology Panel for Directed Energy Weapons examine role of HELSTF as an affordable and cost-effective DoD RDT&E facility to support national HPL and optical tracking programs. Determine how the site can be restructured (facilities and organization) to address users' needs at reduced overhead cost. Assess the cost to automate manual procedures to achieve a cost-effective user-supported facility. Evaluate utility of retaining other-than-MIRACL facilities as well as the entire facility.
- If no funded requirements for use of the Mid-Infrared Advanced Chemical Laser (MIRACL) have been identified, in FY95 the Army will proceed with closing down the MIRACL facility.

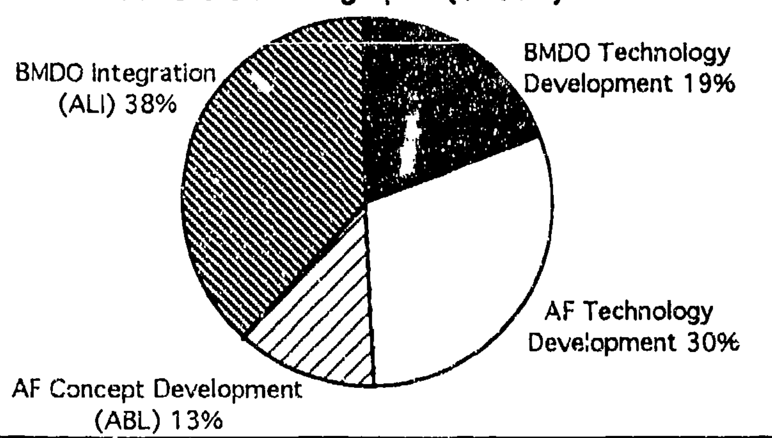
PROGRAM SCHEDULE AND FUNDING SUMMARY

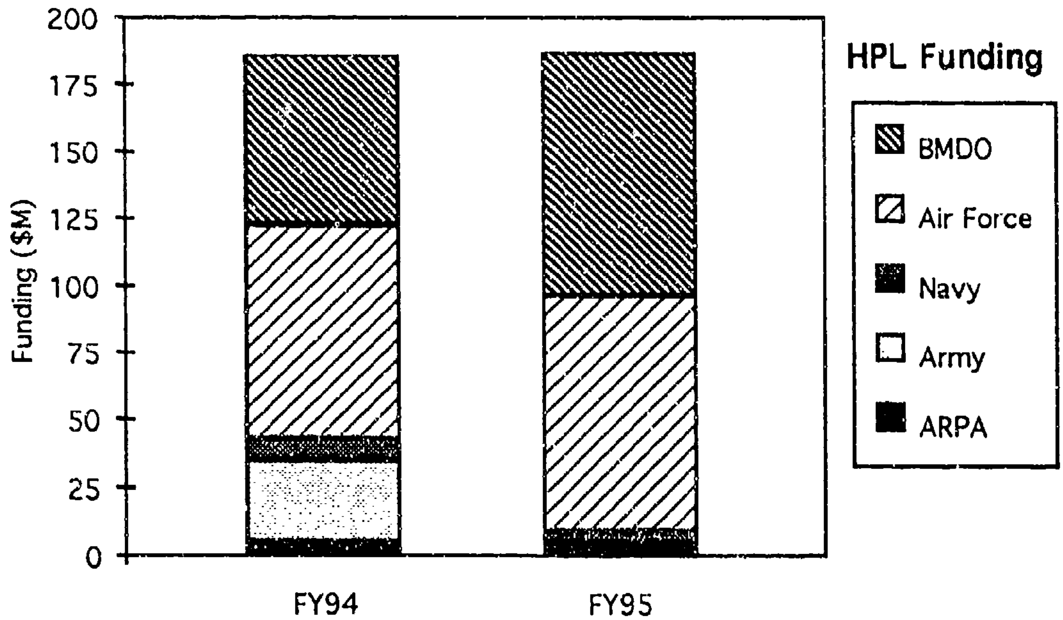
The charts which follow summarize current and projected funding for HPL programs and provide a projected schedule to reach IOC for each application, assuming sufficient funding is available. The schedule shown does not reflect changes which would occur based on the guidance in this document. Funding data are consistent with recently submitted Descriptive Summaries.

It should be noted that the apparent increase in the Air Force 6.2 funding beginning in FY95 is due to a change in bookkeeping practice at the Air Force Phillips Laboratory. Through FY94, laboratory operational funding, including civilian salaries, was a separate 6.2 account so that those costs are not reflected in project accounts reported here. Beginning in FY95 operational costs will be allocated across all project accounts.

The adjacent pie chart depicts the balance within 6.3 funding between FY95 efforts in technology development (49%) and in technology integration (51%).

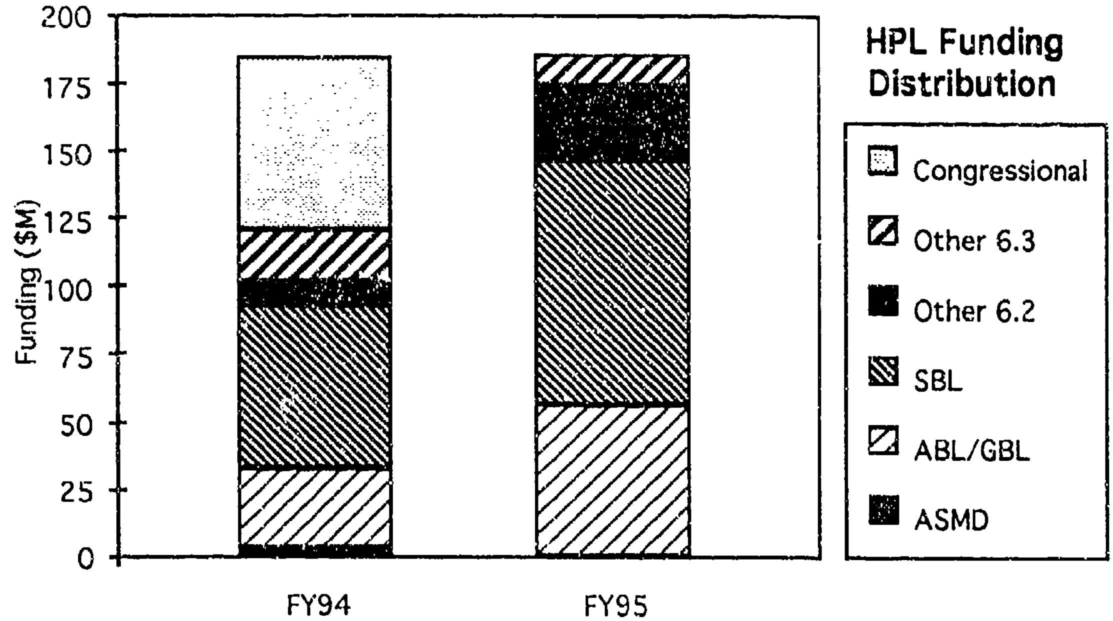
FY95 6.3 Funding Split ($159M)





Service or Agency	Program Element Number	Service/ Agency Identifier	Project Description	Funding ($M) FY94	FY95
Army	602307A	A139	Dye & Diode-pumped Lasers	4.5	
	605605A	HELSTF	Operate HELSTF Facility	24.8	
		Subtotal		29.3	
Navy	602111N	XD1A/X01110	Laser Technology	0.0	3.9
		FEL	Free Electron Laser	5.0	
		PDD	Point Defense Demo	0.8	
	PEO (TAD)	PDD	Point Defense Demo (MIPR)	2.0	
		Subtotal		7.8	3.9
Air Force	602601F	3326	Lasers & Imaging Technology*	3.5	18.4
	603605F	3150	Advanced Optics	6.2	5.0
			Excimer-Active Imaging	10.0	
			Ladar at AMOS	18.4	
		3151	Hi Power Semiconductor Lasers	10.3	6.3
		3647	ABL and GBL Technologies	27.0	36.7
			Excimer-LIME	1.5	
	603319F	ABL	Airborne Laser	1.9	20.0
		Subtotal		78.8	86.4
BMDO	603218C	1302	Chemical Lasers	54.3	77.5
		1305	ATP-Fire Control	6.5	12.5
		F1307	Airborne Laser (Air Force)	0.3	
		A1307	Diode-Pumped Solid State (Army)	1.7	
		N1307	Point Defense Demo (Navy)	0.1	
	603215C	1501	Laser Hardening	0.7	0.6
		Subtotal		63.5	90.6
ARPA	602707E	Lasers	Compact Lasers	5.0	5.0
		6.2/6.3A TOTAL		184.3	185.9

* Funding increase beginning FY95 due to change in accounting practice at Phillips Laboratory



FY94 Congressional adds

High Power Laser Efforts - $64.2M

Service/Agency	PE Number	Project Description	Funds ($M)
Army	602307A 605605A	Dye & Diode-pumped Lasers Operate HELSTF Facility	4.5 24.8
Navy	602111N	Free Electron Laser	5.0
Air Force	603605F	Excimer - Active Imaging Excimer - LIME* Ladar at AMOS	10.0 1.5 18.4

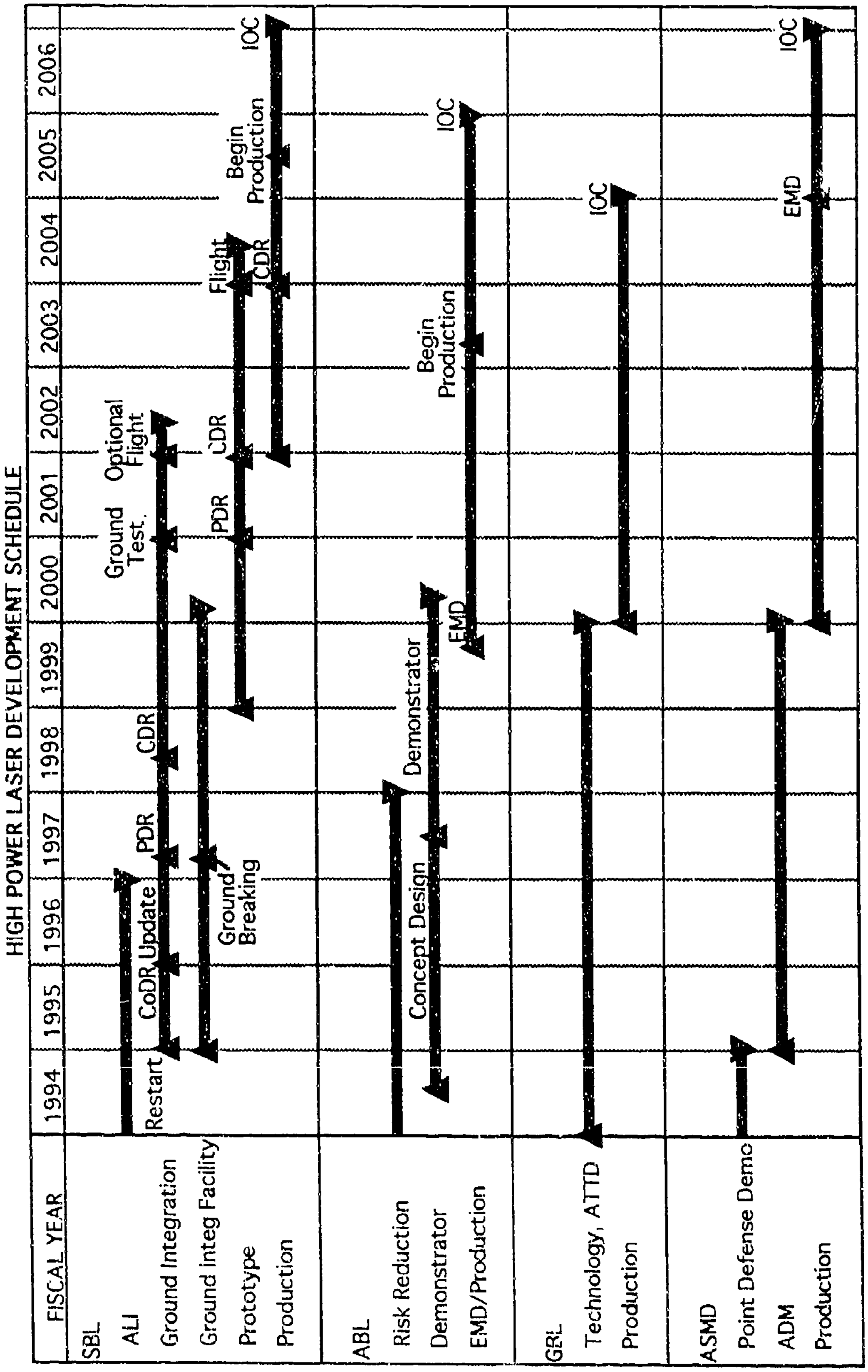
- Army - further develop solid-state dye lasers and diode lasers for both military and medical applications; operate HELSTF until the Navy Point Defense Demo is completed.
- Navy - FEL development, with instructions to continue the existing Army contract.
- Air Force - Excimer laser technology program in two initiatives; one laser-induced microwave effects (LIME), the second investigation and evaluation of laser technology to the problem of high resolution, active imaging of space objects out to geosynchronous altitudes. For laser radar (ladar), development and demonstration of a ladar capability and potential application to space object identification (SOI) and remote sensing. With continued support through FY95, will result in deployment and testing of a capable ladar at AMOS and, with planned added funding from DIA, in testing and evaluation of brassboard ladar hardware on an aircraft.

* $8.5M of the Excimer - LIME effort is funded in the high power microwave line

Upgrade Air Force Maui Optical Station (AMOS) - $32.2M

Service/Agency	PE Number	Project Description	Funds ($M)
Air Force	602601F 603591F	Maui Supercomputer Telescope at AEOS	15.0 17.2

- Air Force - Development, installation, and activation of the Advanced Electro-Optical System (AEOS), a 3.67 meter telescope at AMOS. Maui Supercomputer Center will provide sophisticated and capable imaging processing capability which will significantly improve the ability of the AEOS telescope to support operational requirements for SOI.


HIGH POWER LASER DEVELOPMENT SCHEDULE
FISCAL YEAR
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
SBL
ALI
Ground Integration
Ground Integ Facility
Prototype
Production
ABL
Risk Reduction
Demonstrator
EMD/Production
GBL
Technology, ATTD
Production
ASMD
Point Defense Demo
ADM
Production
Restart
CoDR Update
PDR
CDR
Ground Test
Optional Flight
Ground Breaking
PDR
CDR
Flight
CDR
Begin Production
IOC
Concept Design
Demonstrator
EMD
Begin Production
IOC
IOC
EMD
IOC

GLOSSARY

ABL	Airborne Laser (Air Force)
ADM	Advanced Demonstration Model
AEOS	Advanced Electro-Optical System
AF	Air Force
ALI	Alpha/Lamp Integration, end-to-end ground operation of BMDO SBL concept
Alpha	HF Chemical Laser built by BMDO
AMOS	Air Force Maui Optical Station
ARPA	Advanced Research Projects Agency
ASAT	Anti-satellite
ASMD	Anti-Ship Missile Defense
ATD	Advanced Technology Demonstration (same as ATTD)
ATP	Acquisition, Tracking, and Pointing
ATP/FC	Acquisition, Tracking, Pointing and Fire Control
ATTD	Advanced Technology Transition Demonstration (same as ATD)
BMDO	Ballistic Missile Defense Organization
CD	Compact Disk
CDR	Critical Design Review
CoDR	Concept Design Review
CO_2	Carbon Dioxide (lases at 10.6 μm)
COIL	Chemical Oxygen Iodine Laser (lases at 1.3 μm)
CRDA	Cooperative Research and Development Agreement
D&V	Damage & Vulnerability
DDR&E	Director, Defense Research and Engineering
DEW	Directed Energy Weapons
DF	Deuterium Fluoride (lases at 3.8 μm)
DIA	Defense Intelligence Agency
EMD	Engineering and Manufacturing Development
FEL	Free Electron Laser
GBL	Ground-Based Laser (Air Force)
HABE	High Altitude Balloon Experiment (BMDO)
HELSTF	High Energy Laser System Test Facility at White Sands Missile Range, NM
HF	Hydrogen Fluoride (lases at 2.8 μm)
HPL	High Power Laser
IOC	Initial Operational Capability
IR	Infrared
Ladar	Laser Radar
LAMP	Large Advanced Mirror Program (BMDO)
LIME	Laser-Induced Microwave Effects
MIRACL	Mid Infrared Advanced Chemical Laser (3.8 μm Laser at HELSTF)
O&M	Operations and Maintenance
PDD	Point Defense Demonstration, head-on lethality vs. cruise missiles (Navy)
PDR	Preliminary Design Review
PEO (TAD)	Program Executive Office (Theater Air Defense)
RDT&E	Research, Development, Test and Evaluation
SBL	Space-Based Laser (BMDO)
SBS	Stimulated Brillouin Scattering
SLBD	Sea Lite Beam Director at HELSTF
SOI	Space Object Imaging
SHIELD	System High Energy Laser Demonstration, integrated ground operation of BMDO SBL and ATP
TMD	Theater Missile Defense
TRP	Technology Reinvestment Project (ARPA)
UAV	Unmanned Air Vehicle
USSPACECOM	US Space Command
WSMR	White Sands Missile Range (Army)
μm	micrometer (10^{-6} meter)